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# DIEL FLUCTUATIONS IN CATCH OF POSTLARVAL BROWN SHRIMP, *PENAEUS AZTECUS* IVES, WITH THE RENFRO BEAM TRAWL<sup>1</sup>

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## ABSTRACT

From June 7 through June 11, 1965, two semicircular tows of 100-ft radius (one clockwise and one counterclockwise) were made with the Renfro beam trawl every 2 hours, over a 96-hour period. The sampling site was a tidal flat adjacent to the shoreline of the Gulf of Mexico at Cheniere la Croix, Louisiana. Of the 11,064 postlarval shrimp collected during the sampling, 2088 were identified to species: 1787 (86 per cent) as brown shrimp, *Penaeus aztecus* Ives; 301 (14 per cent) as white shrimp, *P. setiferus* (Linnaeus). The individual sample catches (especially the larger ones) were dominated by brown shrimp. Six major peak catches of post-larvae per tow were observed during the 96-hour period. Four of these occurred on June 7 and June 9: one on each afternoon (at 1400) and another each day about 1 hour after dark (at 2000). These four catches were made when the semidiurnal tide was relatively high. The afternoon peaks were associated with increasing temperature of the water, whereas the peaks after dark occurred as water temperature was decreasing. The remaining two major peaks, observed in daytime after severe squalls, were associated with decreases in water temperature. There was no significant difference between frequency distributions of day and night catches of post-larvae.

## INTRODUCTION

Using a small beam trawl designed by Renfro (1963) for sampling post-larval shrimp in shallow water near the shore, Caillouet, Fontenot & Dugas (1968) observed diel periodicity in catch of postlarval white shrimp, *Penaeus setiferus* (Linnaeus), near Cheniere la Croix on the south side of Marsh Island, Louisiana, bordering the Gulf of Mexico. This and other studies (Tabb, Dubrow & Jones, 1962; Baxter, 1964; St. Amant, Broom & Ford, 1966; Hughes, 1967) have shown that postlarval shrimp, including

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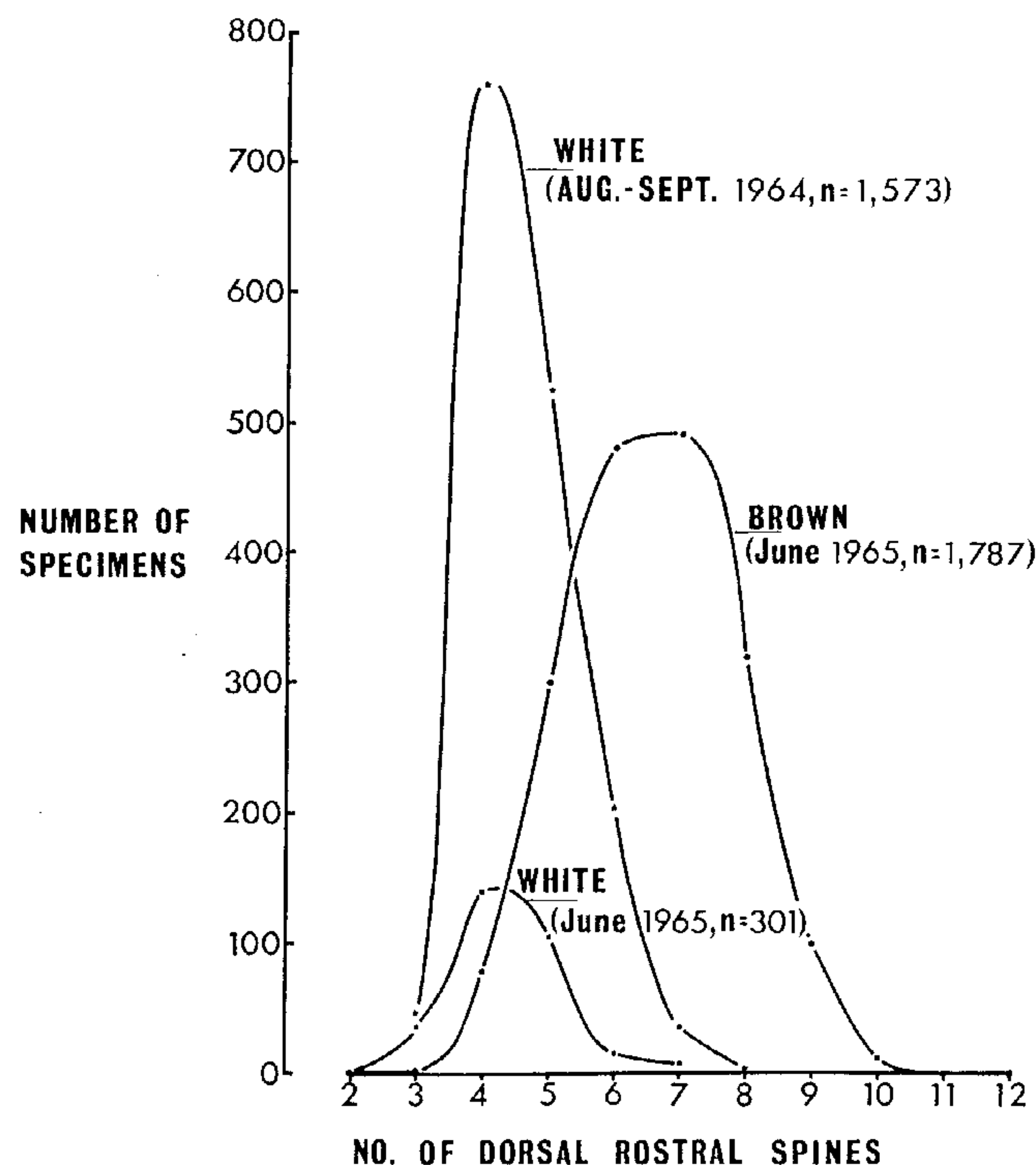


FIGURE 1. Sample frequency distributions of numbers of dorsal rostral spines for postlarval brown shrimp and white shrimp (data for August-September 1964, previously unpublished, were obtained from a study conducted by Caillouet, Fontenot & Dugas, 1968).

white shrimp, pink shrimp (*P. duorarum* Burkenroad), and brown shrimp (*P. aztecus* Ives), migrate passively into estuarine waters with incoming tidal currents.

The purpose of this investigation was to measure diel fluctuations in catch of postlarval brown shrimp.

#### METHODS

From June 7 through June 11, 1965, two semicircular tows of 100-ft radius were made with the Renfro beam trawl every 2 hours (except during squalls) over a 96-hour period near the shoreline of Cheniere la Croix

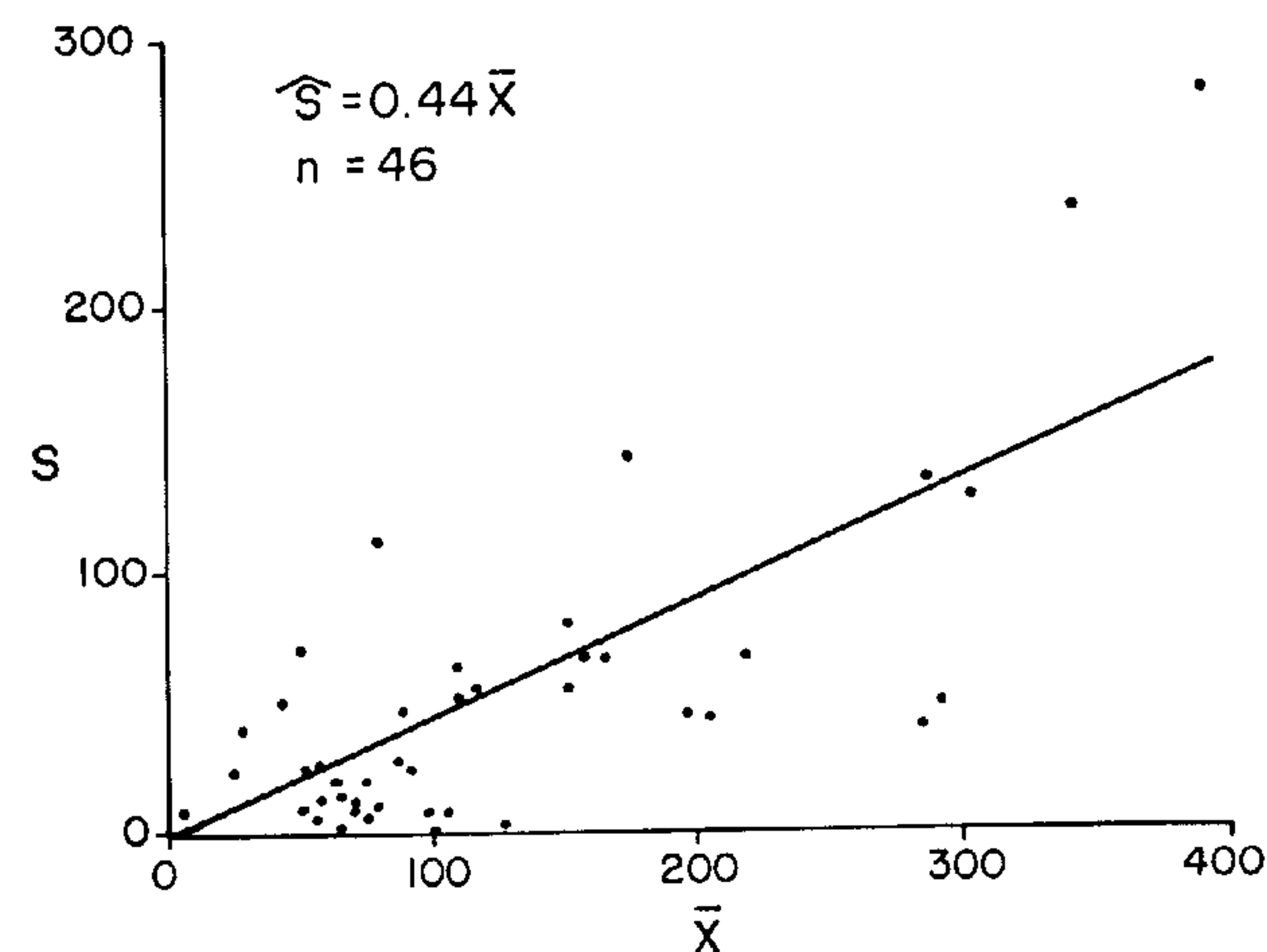


FIGURE 2. Relationship between the standard deviation ( $s$ ) and arithmetic mean ( $\bar{x}$ ) of paired catches of postlarval shrimp. Line fitted through origin and slope of the line calculated according to Snedecor & Cochran (1967:169) as follows:  $b = \Sigma (s/\bar{x})/n$ .

(T 17 S, R 4 E, Section 24). The substrate of the tidal flat at this site was finely ground shell and firm, heavy mud. Radius of tow was measured from the shoreline, and each tow began and ended at the shoreline. The first of each pair of tows was made in a clockwise direction and the second in a counterclockwise direction. Water temperature and change in tidal elevation were recorded each time the two tows were made.

Samples were fixed in 10-15 per cent formalin and 5 per cent glycerol solution buffered with sodium tetraborate decahydrate. Postlarvae were later removed and counted. Subsamples of not more than 25 specimens from each sample were identified to species according to Pearson (1939) and Williams (1959).

#### RESULTS

Of the 11,064 postlarvae collected during the study, 2088 were identified to species. Of those identified, 1787 (86 per cent) were considered to be brown shrimp, and 301 (14 per cent) were considered to be white shrimp, but it is expected that a few may have been misidentified, since there is overlap in certain taxonomic characteristics of the two species in summer (Baxter & Renfro, 1966).

TABLE 1  
RELATIONSHIP BETWEEN CATCH OF POSTLARVAE PER TOW AND SPECIES COM-  
POSITION (PERCENTAGE OF BROWN SHRIMP IN SUBSAMPLES  
OF 25 SPECIMENS) IN 82 SAMPLE TOWS\*

Percentage of brown shrimp†	Catch of postlarvae per tow				Total
	25-49	50-99	100-199	> 199	
36	1	—	—	—	1
40	—	—	—	—	0
44	—	1	—	—	1
48	—	1	1	—	2
52	—	2	—	—	2
56	1	—	—	—	1
60	—	—	1	—	1
64	2	1	1	—	4
68	—	1	1	—	2
72	1	2	—	1	4
76	—	1	1	—	2
80	—	4	1	—	5
84	—	2	—	1	3
88	—	3	2	2	7
92	—	5	2	3	10
96	—	7	7	4	18
100	2	6	6	5	19
Total	7	36	23	16	82

\* For the remaining 10 sample tows, subsamples of fewer than 25 postlarvae were identified to species and are therefore not comparable with those in the table.

† The remaining postlarvae in the subsamples were white shrimp.

The sample frequency distribution of the numbers of dorsal rostral spines (the numbers of spines characterize the various developmental stages) of postlarval white shrimp collected at the same location in the fall of 1964 (Caillouet, Fontenot & Dugas, 1968) had a mode of four, as did the distribution for these spines in postlarval white shrimp collected in June 1965 for the present study (Fig. 1). The distribution for postlarval brown shrimp had a mode of seven dorsal rostral spines (Fig. 1). Postlarval brown shrimp are also larger than postlarval white shrimp in June (Baxter & Renfro, 1966). These two characteristics, number of spines and size, were of some use in identification of the two species.

As was the case in the previous study (Caillouet, Fontenot & Dugas, 1968), the standard deviation of catches (numbers of postlarvae) taken in paired tows was proportional to the arithmetic mean of paired catches from these tows (Fig. 2). The geometric mean catch per tow (square root of the product of catches in paired tows) was therefore used as a measure of fluctuations in relative abundance (Fig. 3). Since the catches, especially

the larger ones, were dominated by brown shrimp (Table 1), it is assumed that the observed fluctuations represent, for the most part, changes in relative abundance of brown shrimp and, to a lesser extent, of white shrimp.

Because two squalls interrupted the sampling, no data were obtained for three scheduled sampling points during the 96-hour period (Fig. 3). An analysis of variance of catches transformed to common logarithms detected significant ( $P < 0.05$ ) differences in catch per tow among the sampling points:

Source of variation	Degrees of freedom	Mean square	F
Among sampling points (2 hours apart)	45	0.4457	2.69*
Within sampling points	46	0.1655	

\* Indicates significant differences at  $P < 0.05$ .

Day and night catches were grouped into five class intervals, but no significant difference could be detected between day and night frequency distributions of these catches (Table 2).

Six major peaks in catch were observed during the 96-hour period (Fig. 3). Four of these occurred on June 7 and June 9, when the patterns of fluctuations in catch were quite similar. On each of these two days, one major peak was observed in the afternoon (at 1400) and another about 1 hour after dark (at 2000), both when the semidiurnal tide was relatively high. The afternoon peaks were associated with increasing temperature of the water, whereas the peaks after dark occurred as water temperature was decreasing.

There was a significant negative correlation ( $r = -0.44$ ) between tide and water temperature. Apparently, the water on the tidal flat was heated

TABLE 2  
FREQUENCY DISTRIBUTIONS OF DAY AND NIGHT CATCHES OF POSTLARVAL  
SHRIMP AT CHENIERE LA CROIX, LOUISIANA, JUNE 7-11, 1965

Catch of postlarvae per tow	Number of tows		
	Day	Night	Total
< 25	4	5	9
25-49	5	2	7
50-99	22	14	36
100-199	16	8	24
> 199	9	7	16
Total	56	36	92

Calculated Chi-square = 1.83 (nonsignificant at  $P < 0.05$ ).



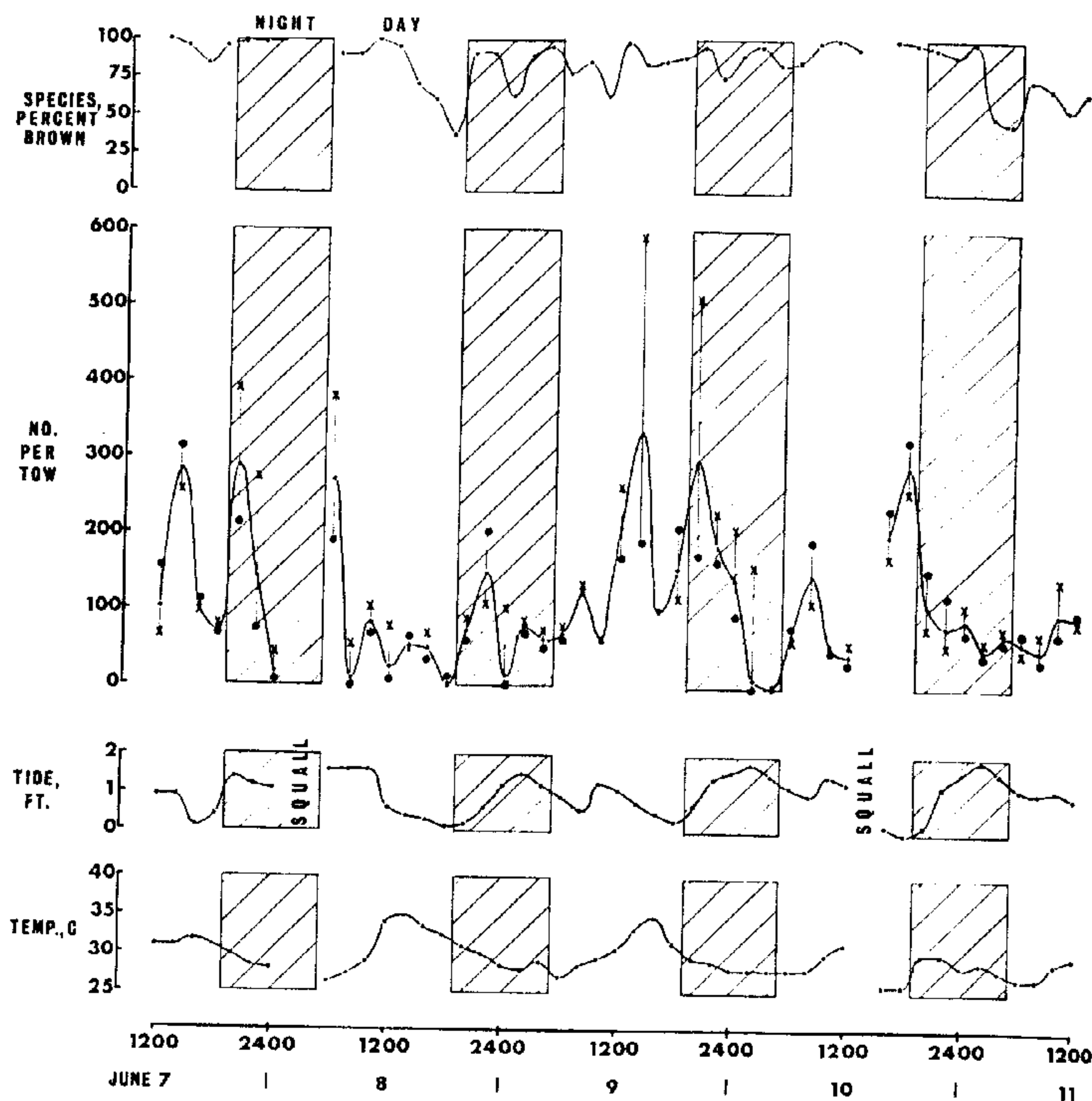


FIGURE 3. Fluctuations in species composition, catch, tide, and water temperature during a 96-hour period of sampling at Cheniere la Croix, Louisiana, June 7 through 11, 1965: Top, species composition (percentage of brown shrimp) of combined subsamples from each pair of catches. Middle, catch (number) of postlarval shrimp per tow. (Vertical lines represent the ranges in catches from the pairs of tows; black circles represent the catches in clockwise tows; x's represent the catches in counterclockwise tows; the continuous line through the points connects the geometric means of the pairs of catches.) Bottom, relative tidal elevation and water temperature.

through insolation during the afternoon near the low-water stage, but water temperature dropped at night with the flooding tide.

The remaining two major peaks in catch, observed following severe squalls, were associated with a decrease in water temperature (Fig. 3). The first was measured about an hour after sunrise (at 0600) at the high-

water tidal stage on June 8, and the second about an hour before sunset (at 1800) at the low-water tidal stage on June 10.

The moon was at first quarter on June 6; therefore moonrise occurred in the afternoon, and moonset after midnight, during the days of the study.

#### DISCUSSION

Caillouet, Fontenot & Dugas (1968) observed a marked diel periodicity in catch of postlarval white shrimp. Peak catches occurred at night, 2-4 hours after the high-water stage.

Tabb, Dubrow & Jones (1962) reported that catches of postlarval pink shrimp were greater at night than during the day and were greater during flood tide than during ebb tide, but Eldred *et al.* (1965) concluded that a nocturnal rhythm is not so persistent in postlarvae of this species. Roessler & Rehner (personal communication) sampled postlarval pink shrimp during four 24-hour sampling periods, one at each of four phases of the moon, in August 1967. The highest catches were obtained at night during the flood tide. Smaller catches were made at night during ebb tide, and the fewest shrimp were taken during the day, regardless of tidal stage. Hughes (1969) showed that an increase in salinity was accompanied by an increase in activity of postlarval pink shrimp. The postlarvae rose from the substrate and were more active when salinity increased. They became less active and settled to the substrate when salinity decreased. Since salinity usually increases with incoming tidal currents, the postlarvae could be passively displaced by such currents when they become active and rise off the substrate in response to the increase in salinity.

De Amant, Broom & Ford (1966) observed greater catches of postlarval shrimp (probably both brown and white shrimp) during periods of incoming tidal currents, but they could detect no relationship between catch and time of day. Baxter (1964) observed that catches of postlarvae (probably brown shrimp) were greater at night than during the day.

Williams & Deubler (1968) suggested that postlarvae (both brown and pink shrimp) in surface plankton are more abundant at night than during the day and that light has a greater influence on postlarval pink shrimp than on postlarval brown shrimp. They suggested further that pink shrimp postlarvae are more abundant on dark nights than on moonlit nights. However, an evaluation of the effect of moonlight on abundance will be difficult, since abundance may be influenced by other lunar effects (e.g., tidal amplitude and its effects on velocity of tidal currents and duration of incoming tides, and interaction of tidal amplitude and moonlight) and by the effect of the lunar cycle on spawning of shrimp (see Munro, Jones & Dimitriou, 1968).

In the present study, there was no significant difference between fre-

quency distributions of day and night catches containing a predominance of postlarval brown shrimp (Table 2).

The amplitude of change in tidal elevation (near 2 ft) was less than that (near 3 ft) in the previous study (Caillouet, Fontenot & Dugas, 1968). This may have contributed to the less pronounced relationship between catch and tide. The two major peaks in catch at night were associated with rising tide and decreasing water temperature, whereas the two afternoon peaks accompanied falling tide and increasing water temperature. In these respects, results are similar to those of Caillouet, Fontenot & Dugas (1968), who observed major peaks in abundance of postlarval white shrimp at the same site at night shortly after the high-water stage when water temperature was low, and who reported minor peaks in the afternoon near the low-water stage when water temperature was high. Either movement of postlarval shrimp occurred on outgoing as well as incoming phases of the tide, or the high temperature of the water in the afternoon may have stimulated activity in the shrimp in the shallow water, or both.

The two severe squalls apparently modified the diel behavior of the postlarvae. Peaks in catch per tow after squalls followed drops in water temperature. The first of these peaks occurred in early morning near the high-water stage, and the second occurred in late afternoon near the low-water stage. It is also possible that, in the latter case, the drop in water temperature and the reduction in incident sunlight by the passing squall may have simulated the conditions of nightfall and thereby influenced the behavior of the postlarvae.

#### ACKNOWLEDGMENTS

This study was supported in part by contract 14-17-0002-100 from the Bureau of Commercial Fisheries, Fish and Wildlife Service, U. S. Department of the Interior; by the University of Southwestern Louisiana, Lafayette, Louisiana; and by a Grant-in-Aid of Research from the Society of the Sigma Xi. We are grateful to Dr. Clarence P. Idyll, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, for critical review of the manuscript. The assistance of Kenneth Breaux, Clarence Callahan, Allen Comeaux, Bennie Fontenot, Conrad Juneau, Ronald Kilgen, and Shelley Nix was greatly appreciated.

#### SUMARIO

#### FLUCTUACIONES DIARIAS EN LA CAPTURA DE POSTLARVAS DEL CAMARÓN CARMELITA, *Penaeus duorarum* IVES, CON LA RED DE VIGA DE RENFRO

Del 7 al 11 de junio de 1965, dos redadas semicirculares de 100 pies de radio (una a favor y otra en contra del movimiento de las manecillas del reloj) fueron hechas cada 2 horas con la red de viga de Renfro durante

un período de 96 horas. El lugar de muestreo fue un bajo expuesto por la marea próximo a la línea de la costa del Golfo de México en Cheniere la Croix, Louisiana. De las 11,064 postlarvas de camarón colectadas durante el muestreo, 2088 fueron identificadas hasta la especie: 1787 (86 por ciento) eran camarones carmelitas, *Penaeus aztecus* Ives y 301 (14 por ciento) camarones blancos, *P. setiferus* (Linnaeus). En las capturas de muestras individuales (especialmente en las más grandes) dominaba el camarón carmelita. Seis puntos de máxima en la captura de postlarvas por redada se observaron durante el período de 96 horas. Cuatro de éstas tuvieron lugar en junio 7 y 9: una cada tarde (1400) y otra cada día alrededor de una hora después de oscurecer (2000). Estas cuatro capturas fueron hechas cuando la marea semidiurna era relativamente alta. Los puntos de máxima captura durante la tarde estuvieron asociados con aumento de la temperatura del agua, mientras que los puntos de máxima después del oscurecer tuvieron lugar a medida que la temperatura del agua bajaba. Los restantes dos puntos de máxima, observados a la luz del día después de fuertes turbonadas, estuvieron asociados con descensos en la temperatura del agua. No hubo diferencia significativa entre las distribuciones de la frecuencia de capturas diurnas y nocturnas de postlarvas.

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